KEATOR

Study of Road-Building Gravels

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STUDY OF ROAD-BUILDING GRAVELS

BY

EDWARD ORRIS KEATOR

THESIS FOR DEGREE OF BACHELOR OF SCIENCE
IN CIVIL ENGINEERING

COLLEGE OF ENGINEERING
UNIVERSITY OF ILLINOIS
PRESENTED JUNE 1902

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May 30 1902

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Edward Orris Keator

ENTITLED Study of Road-Building Gravels

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering

Ira O. Baker

HEAD OF DEPARTMENT OF Civil Engineering

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A Study of Road-building Gravels.

Apparently there has been but little attention given to the qualities of a gravel best fitting it for road-building purposes, — at least there is almost no literature on gravel as a road material. With a view of adding somewhat to the knowledge on this subject, the writer has made a study of a number of well known road gravels.

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We procured several samples of gravel which had given good service on actual road construction, and sought to determine the essential elements of each. Samples were obtained from the following places:

1. Screened gravel from a pit about a mile north east of Urbana, Champaign County Illinois, which had been used in a private driveway in the city of Champaign, Illinois. This sample was selected by Prof. Ira O. Baker.

2. From a pit about two miles north of Decatur Macon County,

Illinois which has given good
service in the public high ways of
the county for a number of years
past. This particular sample was
selected by the highway commissioner
Captain Mahurry, who constructed
the gravel roads and who believes
this to be the best grade used in
or around Decatur. The sample was
selected in the presence of Prof Ira
O. Baker and is believed to be repre
sentative of the pit.

3 — From Rockford Illinois. The
city engineer Mr. Edwin Main,
was informed of the use to which

the gravel was to be put and asked to use special care in selecting a representative sample.

4— From Lexington Mc Lean County Illinois This sample was selected by Mr. J. H. Kerr, the father of gravel roads in that locality, who states that the sample sent us a fair one.

5 From Tuckahill New York. This is a sample of Coa Hook gravel which is much used in and around New York City. It is found on a bar in the Hudson river a short distance below Tuckahill. The sample

was selected by Mr. H. Reynolds, who vouches that it is representative.

6. From the Rock Hill pit at Buckshot New Jersey. Buckshot gravel was recommended by Mr. H. L. Budd State Highway Commissioner of New Jersey, as one of the best in that state. The sample was selected by Mr. Joe Sutton, who is in charge of the pit.

7. This sample was the same as the last above except that it was obtained from the Rock Hill pit.

8. From Shark River New Jersey. Mr Budd also mentioned the gravel

from this locality as being more generally used than any other gravel in New Jersey. The Woburn Park Gravel Company owns the pit and sent this sample.

Method of Procedure

Each sample was carefully examined to determine:

a. The amount and nature of the clay and other matter that is soluble or would be held in suspension by water;

b. The relative sizes of the pebbles;

c. The per cent of voids.

d. The material of which the

pebbles were composed of the mineralogical constituents.

The gravel was dried until all moisture had passed off and then ten kilograms were weighed out which was considered to be as large an amount as could be conveniently handled. This was divided into three parts and each one washed until the water after the last change was clear. In some cases this required from ten to fifteen changes. The washings were put aside until the matter in suspension had settled. When the water had become clear it was drawn off

The gravel was again heated until all moisture had passed off. To make sure of this, it was turned over several times and stirred until the particles did not stick together when a handful was grasped and squeezed. The clay was also dried and weighed. The amount of the latter is stated in Table I. and also in Table II.

Within reasonable limits the relative sizes of the pebbles is a matter of only minor importance except as it affects the percent of voids. The results of a sieve analysis is interesting in this connection in comparing the different

gravels. Then a sieve analysis was made of the washed gravel. Sieves were used having the following diameters of meshes: two inches, one inch, one half of an inch, one fourth of an inch, one twenty seventh of an inch and one fortieth of an inch. Table 1 shows the amount caught on each sieve.

The proportion of voids determines the amount of binder required and the less the better. To determine the percent of voids a vessel holding one thousand and one hundred cubic centimeters was used. It was filled with

gravel and packed by any tapping. The top of the gravel was struck off with a straight edge until the gravel just came to the top of the vessel. Water was then poured in until the gravel was covered. The ratio of the amount of water to the volume of gravel is the percent of voids.

The nature of the pebbles composing a gravel is important as effecting the durability of the gravel when employed as a road building material and also as showing whether any of the harder ingredients on being crushed or decomposed will furnish any binding material. The

pebbles from a weighed portion of washed gravel were sorted according to their mineralogical natures. These pebbles were weighed and their per cents in terms of the whole amount were calculated. Table II gives the results.

Study of Results.

The gravels will be considered in order

1. Urbana. This gravel has 5.5 per cent of voids and only 3.8 per cent of clay. Therefore it is deficient in binder unless some of the other constituents are of such a nature as to furnish it. The two constituents of

the grains which are a source of binder are: the limestone mixed with varying amounts of iron and the acidic crystalline minerals. The limestone when crushed is easily dissolved by the rain and the acids it contains, and serves to bind the mass together. The iron is usually found in the form of an oxide and is more or less soluble in water, which percolating through the mass, deposits about the pebbles a hard crust which cements them firmly together. However the voids are so great in this gravel or the binder is so small that it does

not give a firm road surface.

in Decatur. This gravel has only 4.6 per cent of clay and 30.5 per cent of voids. The ratio of clay to voids is much greater than in the Urbana gravel. However there is more binding material in the other mineral constituents, e.g., this gravel has 21.4 per cent of pure limestone which is of itself a most excellent binder; and in addition there is 8.1 per cent of limestone carrying iron and 11.4 per cent of ferruginous sandstone. Besides there is 10.1 per cent of acidic crystalline pebbles, which when

decomposed form an excellent binding material. In at least four respects then the Decatur is superior to the Urbana gravel, which is sufficient to account for the superiority in practice of the former over the latter.

3. Lexington. This gravel contains 4.2 per cent of clay and 27.3 per cent of voids about the same ratio as for the Urbana gravel. The Lexington gravel differs from the Urbana gravel chiefly by having a very large proportion of siliceous limestone and having a larger proportion of acidic crystalline pebbles. This gravel is

used to make excellent roads.

4 Rockford. The Rockford gravel contains 3.2 per cent of clay and 24.6 per cent of voids. Compounds to the amount of 87.8 per cent containing iron and limestone are present. In the northern part of Illinois Rockford gravel is well known for its good road building qualities.

5 Peekskill. This gravel contains less clay than any of the others, there being present only 0.9 per cent. It has 30.5 per cent of voids and these are filled by lime stone and iron from other compounds.

The amount to 62.6 per cent of the whole. Pike Hill gravel gives good service.

6 Buck Hill Tuckahoe. This gravel contains 20 per cent of clay well mixed with iron oxide; and has 26.5 per cent of voids. In this case there is almost enough clay to bind the mass and besides Table II shows 6 percent of metamorphosed rock containing iron silica and limestone which will furnish some binding material. This gravel makes excellent roads.

7 Rock Hill Tuckahoe. Gravel

from the rock Hill pit a sackabove contains 20.1 per cent of clay and 34 per cent of voids. The aggregate of this gravel consists of quartz and sandstone; and therfore the clay is the only binder. This gravel makes good roads; but it is said that the best results are obtained by mixing equal proportions of this and the preceding gravel.

8. Shark River. This gravel is composed entirely of clay and quartz. The clay amounts to 20.2 per cent and is well mixed with iron oxide. There are present 28.2 per cent of voids.

Under the action of the traffic some of the quartz is ground into powder and mixing with the clay binds firmly. This grave is in extensive use and gives very good results.

Conclusions.

The conclusions to be drawn from the above study are:

1. The voids should be as small as possible.

2. The clay should be nearly equal to the voids, or some of the other mineral constituents should furnish a binding material.

3. Iron oxide is the most

common binder except clay.

4. The acidic crystalline rocks decompose and furnish a binding material

TABLE I.

SIEVE ANALYSIS, CLAY AND VOIDS.

REF. NO.	GRAVEL FROM			SIEVE ANALYSIS OF WASHED GRAVEL. Per cent caught on sieve having meshes — inches in diameter. Through							CLAY.	VOIDS.
	TOWN	COUNTY	STATE	2	1	½	¼	⅛	1/20	1/40		
1.	URBANA.	CHAMPAIGN	ILL.	0.	0	9.87	13.03	53.2	3.9	16.2	3.8	25.5
2.	DECATUR.	MACON	ILL.	0.	0	13.3	10.5	18.7	7.8	40.0	9.6	30.5
3.	LEXINGTON.	McLEAN	ILL.	0.	4.6	10	8.7	35.5	15.9	21.0	4.2	27.3
4.	ROCKFORD.	WINNEBAGO	ILL.	6.0	35.6	23.5	7.4	12.3	2.7	8.7	3.2	29.6
5.	PEEKSKILL.	WESTCHESTER	N.Y.	0.	0	43.4	25.5	20.0	1.8	8.4	.9	30.5
6	TUCKAHOE †	ATLANTIC	N.J.	0.	0.	11.7	11.0	28.8	8.2	20.2	20.0	26.3
7.	TUCKAHOE ‡	ATLANTIC	N.J.	0.	0.	4.0	2.90	29.0	23.6	19.8	20.7	34.0
8	SHARK RIVER.	MONMOUTH	N.J.	0.	0.	.8	12.7	40.7	5.5	20.0	20.2	28.2

† Buck Hill.
‡ Rock Hill.

TABLE II.

MINERALOGICAL ANALYSIS.

REF NO.	MINERALS.	GRAVEL NO.							
		1.	2.	3.	4.	5.	6.	7.	8.
1.	Clay.	3.8	9.6	4.2	3.2	.9	2.0.	20.7	20.2
2.	Quartz.	22.2	23.3	13.7	4.6	22.1	73.9	64.9	78.8
3.	Limestone.— pure.		21.9						
4.	Limestone with varying amounts of iron.	65	8.1	21		33.5			
5.	Limestone.— silicious.			58.3					
6	Limestone with iron and silica.				73.8				
7.	Sandstone finely divided.							10.5	
8.	Sandstone - coarse.							3.8	
9.	Sandstone — ferruginous.		7.4			8.7			
10.	Acidic Crystalline.	4.6	10.1	13.9		15.5			
11.	Basic Crystalline.	4.3	19.7	1.1	4.3	14.2			
12.	Metamorphosed rock — iron, silica, mica.					1.9			
13.	Metamorphosed rock — iron, silica, limestone.						6.0		
14.	Iron conglomerate.				1.74				
15.	Conglomerate — limestone and quartz.				12.3				